# Advanced Storable Propulsion Technologies for Low-Cost Mars Sample Return

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The propulsion requirements of a Mars sample return mission for ascent from the surface of Mars exceed the capabilities of current state-of-the-art propulsion systems. This is particularly true if the mission is to be accomplished using a single launch of an affordable launch vehicle of the Delta III class. This paper will present technical progress to date on four propulsion technologies which can enable such missions:

1. Warm gas pressurization: System studies have shown that the mass of the helium and storage tanks required for a conventional cold-gas pressurization system could approach 20% of the total system dry mass. It appears that about 350/0 of this dry mass can be eliminated by the use of a warm-gas pressurization system which does not require metallic diaphragms or bladders in the propellant tanks.

2. Low temperature propellants: The high freezing point of conventional storable bipropellants drives the thermal control requirements of the ascent propulsion system, increasing the demand for insulation mass, radioisotope heat sources, and/or electrical power while on the surface of Mars. Use of low temperature propellants which have freezing points below -50 “C reduce these demands significantly.

3. Lightweight tanks: Tankage fabricated using conventional technologies would be the largest single contributor to the dry mass of a Mars ascent propulsion system. Composite-overwrapped pressure vessel concepts utilizing new liner fabrication technologies and overwrap materials are described. The goal of the current effort is to demonstrate factor of two reductions in propellant tank mass and reductions of 10 to 20 percent in pressurant tank mass.

4. Lightweight components: due to the requirement for very high propellant fractions on Mars ascent systems, reducing the mass of flow control components has very high leverage for the entire vehicle mass.

In addition to these propulsion technologies, progress in developing lightweight, highly integrated structural concepts for the Mars ascent system will be described.